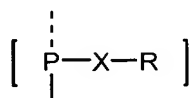


WE CLAIM:

1. A mesoporous synthetic polymer hydrogel permeation layer overlying an electrode on a substrate, wherein the permeation layer comprises mesopores which are between about 100 nm and 1000 nm across.
2. The mesoporous synthetic polymer hydrogel permeation layer of claim 1 wherein the mesopores are between about 100 nm and about 500 nm across.
3. The mesoporous synthetic polymer hydrogel permeation layer of claim 1 wherein the mesopores are between about 200 nm and about 500 nm across.
4. The mesoporous synthetic polymer hydrogel permeation layer of claim 1 wherein the permeation layer further comprises micropores which are between about 1.0 μm and 3.0 μm across.
5. The mesoporous synthetic polymer hydrogel permeation layer of claim 4 wherein the micropores are between about 1.0 μm and 2.0 μm across.
6. The mesoporous synthetic polymer hydrogel permeation layer of claim 4 wherein the micropores are between about 1.0 μm and 1.5 μm across.
7. The mesoporous synthetic polymer hydrogel permeation layer of claim 1 wherein the permeation layer is between about 0.5 μm and about 10 μm thick when dry.
8. The mesoporous synthetic polymer hydrogel permeation layer of claim 1 wherein the permeation layer is between about 1.0 μm and about 5.0 μm thick when dry.
9. The mesoporous synthetic polymer hydrogel permeation layer of claim 1 wherein the permeation layer is between about 1.0 μm and about 2.0 μm thick when dry.
10. The mesoporous synthetic polymer hydrogel permeation layer of claim 1 wherein the polymer comprises a polymerized acryloyl or acrylamido monomer.
11. The mesoporous synthetic polymer hydrogel permeation layer of claim 10 wherein the acryloyl or acrylamido monomer is an acrylamide.
12. The mesoporous synthetic polymer hydrogel permeation layer of claim 10 wherein the acryloyl or acrylamido monomer is an *N*-substituted acrylamide.

13. The mesoporous synthetic polymer hydrogel permeation layer of claim 10 wherein the acryloyl or acrylamido monomer is an *N*-substituted methacrylamide.
14. The mesoporous synthetic polymer hydrogel permeation layer of claim 10 wherein the acryloyl or acrylamido monomer is methacrylamide.
- 5 15. The mesoporous synthetic polymer hydrogel permeation layer of claim 1 wherein the permeation layer is covalently anchored to the electrode.
16. The mesoporous synthetic polymer hydrogel permeation layer of claim 15 wherein the electrode comprises a silicon-containing conductive material.
17. The mesoporous synthetic polymer hydrogel permeation layer of claim 16 wherein the electrode comprises a material selected from the group consisting of: platinum silicide, titanium silicide, gold silicide, and tungsten silicide.
18. The mesoporous synthetic polymer hydrogel permeation layer of claim 1 wherein the permeation layer is covalently anchored to the substrate around the electrode.
19. The mesoporous synthetic polymer hydrogel permeation layer of claim 18 wherein the permeation layer is further covalently anchored to the electrode.
20. The mesoporous synthetic polymer hydrogel permeation layer of claim 1 wherein the permeation layer comprises a copolymerized attachment moiety for the attachment of specific binding entities.
21. The mesoporous synthetic polymer hydrogel permeation layer of claim 20 wherein the specific binding entity is copolymerized with the synthetic polymer hydrogel through a structure of the general formula:



wherein,

P is a polymerizable moiety covalently attached to one or two moieties selected from the group consisting of: a monomeric unit of the synthetic polymer and another P-X-R group, as defined herein, wherein the other P-X-R group may be the same as or different from the first P-X-R group, further

wherein the dashed line is a covalent bond to the second moiety if P is covalently attached to two moieties;

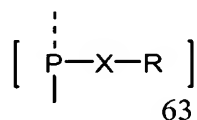
X is a covalent bond or a linking moiety; and

R is a functional moiety for attaching, either covalently or non-covalently, a biomolecule.

22. The mesoporous synthetic polymer hydrogel permeation layer of claim 21 wherein R is attached to a biomolecule.
23. The mesoporous synthetic polymer hydrogel permeation layer of claim 22 wherein the biomolecule is a nucleic acid.
24. The mesoporous synthetic polymer hydrogel permeation layer of claim 22 wherein the biomolecule is a protein.
25. The mesoporous synthetic polymer hydrogel permeation layer of claim 21 wherein R is selected from the group consisting of biotin, avidin, streptavidin, and another biotin binding moiety.
26. The mesoporous synthetic polymer hydrogel permeation layer of claim 21 wherein R is streptavidin.
27. The mesoporous synthetic polymer hydrogel permeation layer of claim 21 wherein R is selected from the group consisting of aldehyde, carboxylic acid, acyl halide, succinimidyl, maleimidyl, thiol, hydrazide, hydrazine, amine, ester, thioester, ketal, and disulfide moieties.
28. The mesoporous synthetic polymer hydrogel permeation layer of claim 21 wherein R is a hydrazide moiety.
29. The mesoporous synthetic polymer hydrogel permeation layer of claim 21 wherein R is a succinimidyl ester moiety.
30. The mesoporous synthetic polymer hydrogel permeation layer of claim 21 wherein R is an aldehyde moiety.
31. The mesoporous synthetic polymer hydrogel permeation layer of claim 21 wherein R is a psoralen moiety.

32. The mesoporous synthetic polymer hydrogel permeation layer of claim 21 wherein P is selected from the group consisting of acrylamide, acrylate, methacrylate, methacrylamide, allyl, amino, and epoxy moieties.
33. The mesoporous synthetic polymer hydrogel permeation layer of claim 21 wherein P is an acryloyl or acrylamido moiety.
34. The mesoporous synthetic polymer hydrogel permeation layer of claim 21 wherein X is a covalent bond.
35. The mesoporous synthetic polymer hydrogel permeation layer of claim 21 wherein X is a polyalkylene glycol linker.
36. A mesoporous synthetic polymer hydrogel permeation layer overlying an electrode on a substrate, wherein the permeation layer has a θ value between about 2.0 and about 4.0 when compared to a standard permeation layer composition S (Acrylamide: Bisacrylamide 19:1 mol/mol, total monomer content 20% by weight).
37. The mesoporous synthetic polymer hydrogel permeation layer of claim 36 wherein the permeation layer has a θ value between about 2.0 and about 3.8 when compared to composition S.
38. The mesoporous synthetic polymer hydrogel permeation layer of claim 36 wherein the permeation layer has a θ value between about 2.0 and about 3.0 when compared to composition S.
39. The mesoporous synthetic polymer hydrogel permeation layer of claim 36 wherein the permeation layer has a θ value between about 3.0 and about 3.8 when compared to composition S.
40. The mesoporous synthetic polymer hydrogel permeation layer of claim 36 wherein the permeation layer is between about 0.5 μm and about 10 μm thick when dry.
41. The mesoporous synthetic polymer hydrogel permeation layer of claim 36 wherein the permeation layer is between about 1.0 μm and about 5.0 μm thick when dry.
42. The mesoporous synthetic polymer hydrogel permeation layer of claim 36 wherein the permeation layer is between about 1.0 μm and about 2.0 μm thick when dry.

43. The mesoporous synthetic polymer hydrogel permeation layer of claim 36 wherein the polymer comprises a polymerized acryloyl or acrylamido monomer.
44. The mesoporous synthetic polymer hydrogel permeation layer of claim 43 wherein the acryloyl or acrylamido monomer is an acrylamide.
45. The mesoporous synthetic polymer hydrogel permeation layer of claim 43 wherein the acryloyl or acrylamido monomer is an *N*-substituted acrylamide.
46. The mesoporous synthetic polymer hydrogel permeation layer of claim 43 wherein the acryloyl or acrylamido monomer is an *N*-substituted methacrylamide.
47. The mesoporous synthetic polymer hydrogel permeation layer of claim 43 wherein the acryloyl or acrylamido monomer is methacrylamide.
48. The mesoporous synthetic polymer hydrogel permeation layer of claim 36 wherein the permeation layer is covalently anchored to the electrode.
49. The mesoporous synthetic polymer hydrogel permeation layer of claim 48 wherein the electrode comprises a silicon-containing conductive material.
50. The mesoporous synthetic polymer hydrogel permeation layer of claim 49 wherein the electrode comprises a material selected from the group consisting of: platinum silicide, titanium silicide, gold silicide, and tungsten silicide.
51. The mesoporous synthetic polymer hydrogel permeation layer of claim 36 wherein the permeation layer is covalently anchored to the substrate around the electrode.
52. The mesoporous synthetic polymer hydrogel permeation layer of claim 51 wherein the permeation layer is further covalently anchored to the electrode.
53. The mesoporous synthetic polymer hydrogel permeation layer of claim 36 wherein the permeation layer comprises a copolymerized attachment moiety for the attachment of specific binding entities.
54. The mesoporous synthetic polymer hydrogel permeation layer of claim 53 wherein the specific binding entity is copolymerized with the synthetic polymer hydrogel through a structure of the general formula:



wherein,

P is a polymerizable moiety covalently attached to one or two moieties selected from the group consisting of: a monomeric unit of the synthetic polymer and another P-X-R group, as defined herein, wherein the other P-X-R group may be the same as or different from the first P-X-R group, further wherein the dashed line is a covalent bond to the second moiety if P is covalently attached to two moieties;

X is a covalent bond or a linking moiety; and

R is a functional moiety for attaching, either covalently or non-covalently, a biomolecule.

55. The mesoporous synthetic polymer hydrogel permeation layer of claim 54 wherein R is attached to a biomolecule.
56. The mesoporous synthetic polymer hydrogel permeation layer of claim 55 wherein the biomolecule is a nucleic acid.
57. The mesoporous synthetic polymer hydrogel permeation layer of claim 55 wherein the biomolecule is a protein.
58. The mesoporous synthetic polymer hydrogel permeation layer of claim 54 wherein R is selected from the group consisting of biotin, avidin, streptavidin, and another biotin binding moiety.
59. The mesoporous synthetic polymer hydrogel permeation layer of claim 54 wherein R is streptavidin.
60. The mesoporous synthetic polymer hydrogel permeation layer of claim 54 wherein R is selected from the group consisting of aldehyde, carboxylic acid, acyl halide, succinimidyl, maleimidyl, thiol, hydrazide, hydrazine, amine, ester, thioester, ketal, and disulfide moieties.
61. The mesoporous synthetic polymer hydrogel permeation layer of claim 54 wherein R is a hydrazide moiety.
62. The mesoporous synthetic polymer hydrogel permeation layer of claim 54 wherein R is a succinimidyl ester moiety.

63. The mesoporous synthetic polymer hydrogel permeation layer of claim 54 wherein R is an aldehyde moiety.
64. The mesoporous synthetic polymer hydrogel permeation layer of claim 54 wherein R is a psoralen moiety.
- 5 65. The mesoporous synthetic polymer hydrogel permeation layer of claim 54 wherein P is selected from the group consisting of acrylamide, acrylate, methacrylate, methacrylamide, allyl, amino, and epoxy moieties.
66. The mesoporous synthetic polymer hydrogel permeation layer of claim 54 wherein P is selected an acryloyl or acrylamido moiety.
- 10 67. The mesoporous synthetic polymer hydrogel permeation layer of claim 54 wherein X is a covalent bond.
68. The mesoporous synthetic polymer hydrogel permeation layer of claim 54 wherein X is a polyalkylene glycol linker.
- 15 69. A method of producing a mesoporous synthetic polymer hydrogel permeation layer overlying an electrode on a substrate, the method comprising:
 - a) placing an appropriate volume of a polymerization mixture comprising polymerizable monomers, a cross-linking agent, and a porogen capable of generating mesopores into a mold cavity of a micromold, wherein the mold cavity comprises a bottom and at least one side;
 - 20 b) contacting a substrate, comprising a plurality of electrodes on the substrate, with the mold to form a closed volume of the polymerization mixture, wherein the closed volume is in contact with at least one of the electrodes on the substrate;
 - c) polymerizing the polymerization mixture to form a mesostructured synthetic polymer hydrogel permeation layer; and
 - 25 d) removing the micromold.
70. The method of claim 69 wherein the porogen is an templating porogen, the method further comprising selectively removing the templating porogen from the mesostructured synthetic polymer hydrogel permeation layer after step (c).
71. The method of claim 70 wherein the templating porogen is a micelle forming surfactant.

72. The method of claim 71 wherein the micelle forming surfactant is a nonionic surfactant.
73. The method of claim 71 wherein the micelle forming surfactant comprises a polyether and an aliphatic carbon chain.
74. The method of claim 71 wherein the micelle forming surfactant is a Brij surfactant with a molecular weight between 100 and 10,000.
75. The method of claim 71 wherein the micelle forming surfactant is a Brij surfactant with a molecule weight between 4500 and 5000.
76. The method of claim 71 wherein the selective removal of the template porogen comprises rinsing the permeation layer with an aqueous solvent.
77. The method of claim 70 wherein the polymerization mixture comprises a heat-activatable polymerization initiator, the method further comprising heating the closed volume of the polymerization mixture to initiate polymerization.
78. The method of claim 70 wherein the polymerization mixture comprises a photo-activatable polymerization initiator, the method further comprising irradiating the closed volume of the polymerization mixture with an appropriate wavelength of light to initiate polymerization.
79. The method of claim 70 wherein the polymerization mixture comprises a redox-activatable polymerization initiator.
80. The method of claim 78 wherein at least a portion of the mold cavity of the micromold is transparent to the appropriate wavelength of light.
81. The method of claim 69 wherein the surface of the at least one electrode contacting the closed volume has been derivatized with an anchoring moiety comprising a copolymerizable moiety.
82. The method of claim 81 wherein the copolymerizable moiety is an acryloyl or acrylamido moiety.
83. The method of claim 69 wherein a surface of the substrate is in contact with the closed volume, further where the surface of the substrate has been derivatized with an anchoring moiety comprising a copolymerizable moiety.

84. The method of claim 83 wherein the copolymerizable moiety is an acryloyl or acrylamido moiety.
85. The method of claim 69 wherein the polymerization mixture further comprises a copolymerizable attachment moiety for the attachment of specific binding entities.

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